AMMONIUM NITRATE AND POULTRY MANURE IN FERTILIZATION OF TOBACCO

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AMMONIUM NITRATE AND POULTRY MANURE IN FERTILIZATION OF TOBACCO

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The experiments reported in this bulletin were begun during World War II when nitrogenous materials suitable for fertilization of tobacco were both scarce and expensive. Growers had difficulty in filling their customary requirements for cottonseed meal and other organics. These conditions led to a search for other materials that could replace a part, if not all, of the organics.

One which showed promise was ammonium nitrate, another was poultry manure. The tests with these materials were carried out independently of one another and are reported in separate sections.

The account of this work is presented when again there is a national emergency with high prices and anticipated scarcity of many commodities, including nitrogenous materials ordinarily used in tobacco fertilizer mixtures.

[1] Tobacco Laboratory, Windsor.

AMMONIUM NITRATE

Ammonium nitrate contains 32.5 per cent nitrogen in about equal proportions of ammonia and nitrate nitrogen. The material is very deliquescent as it comes from the processing chambers and conditioning is necessary to make it safe to handle. It is now marketed in the Connecticut Valley in pellet form under the name of "Nitropills".

To fill war needs, government-sponsored plants produced large quantities of the material. In 1943 the needs of the armed forces were met and a fair supply could be released for use in agriculture.

Although today nitrogen for agricultural use is more abundant, the organic forms so widely used by tobacco growers are two to three times as high in price as synthetic nitrogen.

Scope of Experiment

The varying effects of different nitrogenous materials on yield and quality of tobacco have been determined from time to time at the Tobacco Laboratory. The value of ammonium nitrate for this crop was tested in a series of field experiments, begun in the spring of 1944. They were conducted for five years on the same field in order to observe seasonal variations. The experiments were designed to obtain answers to the following questions:

1. Can ammonium nitrate be used profitably as the sole source of nitrogen in fertilizer mixtures?

2. What is the relative efficiency of this type of nitrogen in comparison with that in cottonseed meal?

3. Are there advantages in applying it in fractions at intervals during the growing season, since it is readily soluble?

4. Can the material be applied to advantage as a supplement to a mixture of commercial grade?

The soil of the test field selected for this experiment is a fine sandy loam of the Merrimac series. The subsoil, however, is somewhat tighter than most Merrimac soils on the Experimental Farm. For the two previous years, vegetables had been grown on the field but before that, it had been planted to tobacco for an extended period of years.

Twenty-four plots of 1/40 acre each, sufficient to furnish quadruplicates for each treatment, were laid out. All the plots were in randomized block arrangement. The field was planted to Havana Seed tobacco which was harvested for obtaining data on yield and grading.

The nitrate content of the soil was determined at regular intervals during the growing seasons, in order to compare the capacity of ammonium nitrate to supply nitrate with that of cottonseed meal.

Weather Conditions During the Five-year Period

Figure 1 shows the trend of rainfall during the growing seasons of 1944 through 1948. The graphs are based on data in Table 1.

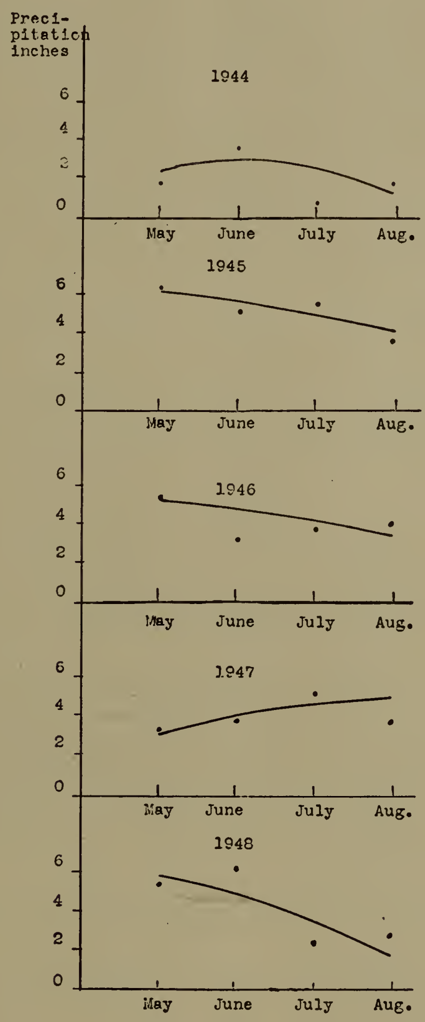

Figure 1. Graphical resumé of precipitation trends during growing seasons of 1944 through 1948.

Rainfall in 1944 was scanty and the growing season became extremely dry at the end. The early part of the 1945 season was quite wet, while dry weather was more or less continuous from the latter part of July up to harvesting time. There was ample moisture for starting the tobacco crop in 1946, but a severe drought extended from the middle of June through

TABLE 1. RAINFALL FOR THE GROWING SEASONS OF 1944-1948

Month		Date	Inches of rainfall by 10-day periods				
			1944	1945	1946	1947	1948
May		1-10	.08	1.93	.80	1.82	.85
		11-20	...	3.53	2.00	.34	2.35
		21-31	1.85	.65	2.85	1.16	2.25
	Total for May		1.93	6.11	5.65	3.32	5.45
	Mean since 1922		3.39	3.33	3.43	3.47	3.64
June		1-10	.10	.69	2.10	1.50	1.90
		11-20	1.80	2.59	.70	.55	2.20
		21-30	1.78	1.30	.14	1.86	2.00
	Total for June		3.68	4.58	2.94	3.91	6.10
	Mean since 1922		3.88	3.87	3.80	3.83	3.92
July		1-10	.13	1.30	.46	.70	.95
		11-20	.58	3.15	.05	2.18	.80
		21-31	.59	.32	3.43	2.66	.53
	Total for July		1.30	4.77	3.94	5.54	2.28
	Mean since 1922		3.59	3.49	3.51	3.60	3.55
August		1-10	.56	1.40	1.73	.65	.54
		11-20	1.14	...	1.67	2.20	2.09
		21-31	.22	2.35	.60	.80	...
	Total for August		1.92	3.75	4.00	3.65	2.63
	Mean since 1922		3.90	3.81	3.82	3.81	3.76

three weeks of July. In 1947 moderate rains all through the season provided ample soil moisture, yet no leaching of plant food occurred. The earlier part of the 1948 season was extremely wet and some leaching of available nitrogen took place. From this resumé it is seen that weather conditions varied considerably in the five-year period. As will be noticed later, these variations were reflected in yield and quality of tobacco, as well as in nitrate levels of the soil.

Ammonium Nitrate As a Single Source of Nitrogen

The 16 plots included in this series were quadruplicate tests on applications of 150, 175 and 200 pounds of nitrogen to the acre as ammonium nitrate in the fertilizer mixture. These rates were compared with the rate of 200 pounds of nitrogen in cottonseed meal. The other essential plant foods were furnished at equal rates for all treatments.

The three different rates of nitrogen from ammonium nitrate were used in an attempt to ascertain whether nitrogen in that form was more "efficient"[1] than cottonseed meal nitrogen.

[1] **"Efficiency" of a nitrogenous material refers to its relative capacity to supply available nitrogen to the growing crop as compared with the performance of cottonseed meal. Efficiency is not always proportional to the percentage of "available nitrogen" determined by the fertilizer chemist.**

TABLE 2. FIVE-YEAR SUMMARY, YIELD AND GRADING RECORDS OF AMMONIUM NITRATE SERIES
(Cottonseed Meal Compared With Three Rates of Ammonium Nitrate)

Kind and amount of N per A.	Treat-ment	Blocks	Yield, pounds per acre 1944	1945	1946	1947	1948	Av.	Grade index[1] 1944	1945	1946	1947	1948	Av.	Crop index[2]	Relative crop value
200 lbs.		1	1992	2414	1986	2142	2037	2114	.409	.455	.472	.456	.379	.434		
N in		2	2094	2367	1984	2174	1650	2054	.367	.520	.420	.454	.435	.439		
cottonseed	A	3	1801	2345	1833	1976	1761	1943	.388	.471	.388	.455	.375	.415		
meal		4	1728	2226	1918	2111	1740	1945	.354	.479	.417	.460	.370	.416		
			Average for 5-year period					2014						.426	858.0	100.0
150 lbs.		1	1953	2156	1873	2038	1717	1947	.330	.427	.420	.424	.341	.388		
N in		2	2071	2203	1819	2100	1800	1999	.433	.448	.423	.434	.361	.420		
ammonium	B	3	1508	2226	1652	2221	1846	1891	.367	.509	.371	.454	.359	.412		
nitrate		4	1754	2180	1789	2196	1762	1936	.360	.476	.401	.439	.356	.406		
			Average for 5-year period					1943						.497	790.8	92.2[3]
175 lbs.		1	1931	2438	1934	2276	1913	2098	.405	.441	.441	.484	.370	.428		
N in		2	2020	2204	1917	2304	1800	2049	.394	.481	.422	.482	.387	.433		
ammonium	C	3	1785	2175	1779	2089	1701	1906	.366	.438	.424	.437	.378	.409		
nitrate		4	1712	2343	1836	2196	1858	1989	.375	.471	.414	.421	.389	.414		
			Average for 5-year period					2011						.421	846.6	98.7[4]
200 lbs.		1	1988	2250	1840	2171	1725	1995	.405	.416	.412	.423	.366	.404		
N in		2	1943	2039	1781	2143	1772	1936	.416	.447	.400	.440	.369	.414		
ammonium	D	3	1706	2344	1725	2062	1843	1936	.346	.478	.438	.506	.399	.433		
nitrate		4	1606	2250	1654	2222	2036	1954	.347	.431	.348	.446	.388	.392		
			Average for 5-year period					1955						.411	803.5	93.6[4]

[1] Grade index measures the RELATIVE value of a lot of tobacco computed from the percentage weight of each grade of leaves in the lot and the relative values of these grades. Assuming that the light wrapper is the perfect leaf of Havana Seed tobacco, it is assigned a value of 1.00. The other grades are assigned values in the same proportion to 1.00 as their market value bore to the price of the light wrapper when this system was established. Here medium wrappers have a value of 0.60; long seconds (19 inches or more), 0.60; short seconds (15 and 17 inches), 0.30; long darks, 0.30; dark stemming (short darks of 15 and 17 inches), 0.20; fillers and brokes, 0.10. The values of these grades have fluctuated during the years that we have used this system of grading but, in order to average results over a period of years, the same system has been retained. To obtain the grade index figure, the percentage of each grade in a lot of tobacco is multiplied by the relative values noted above, the products are added and the sum is divided by 100.

[2] Crop index is the product of grade index multiplied by the yield figure.

[3] Significant at odds 19 to 1.

[4] Not significant.

In the five-year period, yield and gradings were nearly the same for cottonseed meal at 200 pounds of nitrogen per acre and the 175 pound rate of nitrogen from ammonium nitrate. It is, therefore, indicated that nitrogen in ammonium nitrate is about 12.5 per cent more efficient than in cottonseed meal (Table 2).

The lower rate, 150 pounds, produced results fully as good as 200 pounds of cottonseed meal nitrogen in 1945. Hardly any leaching rain occurred during the growing season of that year.

Under favorable weather conditions, no greater return resulted from applying 200 pounds of nitrogen from ammonium nitrate to the acre than from the 175 pound rate or the use of cottonseed meal. This is a further indication that the optimum quantity of nitrogen per acre was satisfied at the rate of 175 pounds or even at the lower rate under favorable conditions.

Nitrate Levels in the Soil During the Growing Season

In spite of crop withdrawal, loss by leaching, fixation of nitrogen, and possibly other circumstances, the nitrate content of the soil under a growing crop may be taken as a criterion on production of available nitrogen in comparison of sources. In the course of this experiment, soil samples were analyzed at regular intervals during four of the growing seasons.[1]

Results from nitrate determinations for the various years (1945 was the year omitted) are shown in Tables 3, 4 and 5. In the first year of this experiment, 1944 (Table 3), it was shown that even the lowest rate of nitrogen (150 pounds per acre) produced about 12 per cent more nitrates than the 200 pound rate of cottonseed meal nitrogen. This is consistent with the very dry weather of that year. In assuming that the nitrogen in ammonium nitrate was 100 per cent available, only 67 to 68 per cent of the cottonseed meal would be available. This is based on a comparison of the seasonal averages of the soil nitrates of ammonium nitrate plots with those of the cottonseed meal plots. This finding is considerably higher than that previously established for cottonseed meal by Rubins and Bear,[2] who estimated the availability of nitrogen to be 54 per cent. Morgan and Jacobson[3] found in lysimeter studies that 72.5 per cent of the cottonseed meal nitrogen was liberated, but only 51 per cent was available to the crop. Therefore, under certain favorable conditions, it may be possible that the liberated cottonseed meal nitrogen is less subject to fixation.

In the season of 1946 the nitrate levels were considerably higher than in 1944. The season of 1945 was, in general, fairly dry and residual nitrogen was doubtless carried over to the following year. It is interesting to note that about 87 per cent of the cottonseed meal nitrogen appeared in nitrate

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[1].The nitrate content was determined according to standard method, using phenoldisulfonic acid.

[2] Rubins, Edward J., and Firman E. Bear. Carbon-nitrogen ratio in organic fertilizer materials in relation to the availability of their nitrogen. Soil Sci. 54 (6): 411-423. 1942.

[3] Morgan, M. F., and H. G. M. Jacobson. Soil and crop interrelations of various nitrogenous fertilizers. Conn. Agr. Expt. Sta. Bul. 458: 321. 1942.

TABLE 3. NITRATE NITROGEN LEVELS IN SOILS FROM COTTONSEED MEAL AND AMMONIUM NITRATE PLOTS, 1944 AND 1946

Source of nitrogen	Lbs. N applied per A.	Parts per million of nitrate nitrogen in the soil									Relative number
		May 29	June 9	June 20	June 29	July 11	July 19	July 27	Aug. 7	Seasonal average	
1944											
Cottonseed meal	200	9.5	35.0	43.0	43.2	49.7	60.5	50.7	34.0	50.7	100.0
Ammonium nitrate	150	38.3	50.5	73.0	33.5	68.2	72.0	71.7	45.4	56.6	111.6
Ammonium nitrate	175	39.6	49.7	93.2	41.2	91.2	78.5	73.2	62.7	66.2	130.6
Ammonium nitrate	200	57.1	60.1	107.3	60.2	94.7	101.7	69.8	71.5	77.8	153.5
Average seasonal trend of nitrate levels		36	49	79	45	76	78	65	53		
1946											
		May 29	June 10	June 20		July 1	July 11	July 22	Aug. 1		
Cottonseed meal	200	39.6	47.5	84.9		79.0	79.0	172.3	106.0	86.9	100.0
Ammonium nitrate	150	37.0	68.1	85.5		88.0	88.0	122.9	63.5	77.6	89.2
Ammonium nitrate	175	51.6	81.8	96.0		112.0	93.2	156.5	43.8	90.7	104.4
Ammonium nitrate	200	44.9	85.1	93.0		101.3	110.0	181.9	47.2	94.8	109.1
Average seasonal trend of nitrate levels		43	70	90		95	93	158	65		

TABLE 4. NITRATE NITROGEN LEVELS IN SOILS FROM COTTONSEED MEAL AND AMMONIUM NITRATE PLOTS, 1947

Source of nitrogen	Lbs. N applied per A.	Sampling depth	Parts per million of nitrate nitrogen in the soil							
			June 12	June 23	July 7	July 17	July 28	Aug. 7	Average for depth	Seasonal average
Cottonseed meal	200	7″	106.0	80.7	67.7	86.0	16.4	10.1	61.1	
		14″	63.5	65.2	57.4	64.0	20.1	11.4	46.9	45.8
		21″	41.0	37.1	37.5	32.5	18.8	12.7	29.6	
Ammonium nitrate	150	7″	138.0	106.0	157.4	111.3	81.8	66.8	110.0	
		14″	63.0	87.1	101.2	74.4	91.7	51.8	78.2	76.0
		21″	31.0	57.9	57.5	31.8	36.6	24.8	29.9	
Ammonium nitrate	175	7″	179.3	100.0	115.2	114.6	74.4	60.0	107.3	
		14″	63.0	75.0	78.2	58.0	38.9	27.3	56.7	65.3
		21″	43.3	45.0	45.2	19.4	19.6	18.7	31.9	
Ammonium nitrate	200	7″	229.5	217.6	225.0	166.7	101.6	65.0	167.6	
		14″	105.3	122.4	94.8	98.0	90.0	43.0	92.3	100.9
		21″	45.3	65.0	41.7	39.5	36.3	29.6	42.9	

form. This suggests that, if a high nitrate level is maintained in the soil, the power of denitrification (or other fixation forces) is greatly diminished.

Since there seemed to be a tendency towards accumulation of soil nitrates from one year to another, it was decided to sample the soil at different depths during the season of 1947. Previously all sampling was made to a depth of seven inches. In 1947 samples were collected in cores at depths of 7 inches, 14 inches and 21 inches. The results (Table 4) from nitrate determinations show a large accumulation of nitrates at greater depths. Characteristic of all treatments was the fact that on June 12 (only two weeks after fertilizer application with no appreciable amount of leaching rains) there were from 63 to 105 parts per million of nitrate nitrogen at the 14-inch depth, approximately the equivalent of 125 to 200 pounds of nitrogen on an acre basis; thus sufficient nitrogen for an entire crop. Besides, the surface seven inches of soil at that time contained more nitrogen than could be accounted for from the spring fertilization.

Furthermore, ammonium nitrate seemed to cause about 80 per cent greater accumulation of nitrates than cottonseed meal. That is in accord with only about 56 per cent availability of cottonseed meal nitrogen. This, in turn, is in agreement with a lower level of soil nitrates (in the surface seven-inch layer) obtained in 1947 than in 1946.

It is of interest to note that, in spite of the heavy accumulation of available nitrogen in the soil, the crop grown with ammonium nitrate in 1947 was fully comparable in all respects to that grown with cottonseed meal. This is quite contrary to previous findings and to common opinion among growers which is that an overabundance of nitrogen has an adverse effect on quality.

TABLE 5. NITRATE NITROGEN LEVELS IN SOILS FROM COTTONSEED MEAL AND AMMONIUM NITRATE PLOTS, 1948

Source of nitrogen	Treatment	Blocks	Lbs. N applied per A.	Parts per million of nitrate nitrogen in the soil: June 17	July 1	July 15	July 29	Aug. 4	Seasonal average	Av. for material
Cottonseed meal	A	1	200	6.71	5.61	8.95	5.27	2.16	5.74	
		2		8.86	3.92	5.75	5.92	4.12	5.71	
		3		6.71	3.44	9.29	3.77	2.94	5.23	
		4		7.43	4.70	4.44	6.53	4.48	5.52	5.55
Ammonium nitrate	B	1	150	8.61	2.76	11.49	5.37	6.91	7.03	
		2		8.61	2.04	2.07	4.08	1.27	3.61	5.32
	C	1	175	11.65	1.27	5.75	7.56	8.54	6.95	
		2		13.80	4.06	7.36	3.26	3.94	6.48	6.72
	D	1	200	11.36	4.41	10.28	9.35	6.00	8.28	
		2		14.05	3.19	6.35	3.37	10.65	7.52	7.90
Seasonal trend				9.78	3.64	7.17	5.45	5.10		

The nitrate contents of the soil during the season of 1948 present an entirely different picture. From a glance at Table 5 it is learned that the nitrate levels all through the season were extremely low. Only traces of nitrate nitrogen were found before application of fertilizer (May 15). The heavy rainfalls in late spring and early summer had completely drained off the surplus accumulated for two to three years. Thus, there was little chance for accumulation of nitrates in the soil in the competition of leaching rains and crop withdrawal. The yield per acre was about 16 per cent lower and the grade index 8 per cent lower for the crop of 1948 than for that of 1947. The 150 pound rate of nitrogen, with the lowest seasonal average of nitrate content in the soil, produced an inferior crop, with a great part of the leaves being yellowish, due to insufficient supply of nitrogen. Although the seasonal average for cottonseed meal was only slightly higher, the supply was evidently sufficient to prevent "starving". Most of the leaves, however, lacked the desirable "finish". The same may be said about the 175 and 200 pound rates of nitrogen from ammonium nitrate.

The above results show that the excessive rainfalls early in the season of 1948 depleted the nitrogen supply to such an extent that extra nitrogen should have been applied as a side dressing. This would have been done in general farm practice.

Fractional Applications of Ammonium Nitrate

Although ammonium nitrate is a readily water-soluble material, the ammonium radical is much less subject to leaching than the nitrate portion. Thus, when leaching rains occur, a substantial part of the nitrogen would be little or not at all affected. It was thought that applying the equivalent of 200 pounds of nitrogen to the acre in fractions should diminish the chances of nitrate losses from heavy rainfalls, commonly occurring early in the season. Also, by this method an excess of available plant food might be avoided, since heavy concentrations of ammonium compounds are known to be detrimental to development of the tender roots of young plants.

Over the period of five years a series of four plots received one-fifth of the nitrogen in ammonium nitrate, applied together with the full requirements of other fertilizer ingredients before the crop was planted, one-fifth at the time of planting, and the balance in equal portions at 10-day intervals.

In the years when no leaching occurred, the results from the fractional method were similar to those where all the nitrogen was applied at one time. Contrary to expectations, the method was of no advantage with the amount of leaching that occurred in 1948. On the average, in the five-year period, the crop values were considerably lower than when 200 pounds of nitrogen was applied all at one time.

In Table 6 it is found that the average relative crop value for fractional application of ammonium nitrate amounts to only 89.4 in comparison to 100 for the material used in one single application. The difference is highly significant (odds 99 to 1). Therefore, a practice that involves more work than usual and is not profitable in the long run is not worth considering.

TABLE 6. FIVE-YEAR SUMMARY, YIELD AND GRADING RECORDS OF AMMONIUM NITRATE SERIES
(Two Hundred Pounds Ammonium Nitrate Applied in Fractions Compared With The Same Amount Applied All At One Time)

Source of nitrogen	Treat-ment	Blocks	Yield, pounds per acre						Grade index						Crop index	Relative crop value
			1944	1945	1946	1947	1948	Av.	1944	1945	1946	1947	1948	Av.		
200 lbs. N		1	1988	2213	1837	1977	1839	1971	.387	.412	.393	.380	.372	.389		
in ammonium		2	1594	1946	1685	1944	2118	1857	.322	.400	.370	.411	.385	.378		
nitrate,	E	3	1709	2003	1837	1747	1667	1793	.373	.419	.433	.366	.355	.389		
application		4	1645	1983	1809	1823	1933	1839	.336	.401	.396	.407	.375	.383		
in fractions																
			Average					1865						.385	718.0	89.4[2]
	Average of five years for 200 pounds N in ammonium nitrate in one application[1]							1955						.411	803.5	100.0

[1] See Table 2 for individual year and plot figures.
[2] Significantly lower than check; odds 99 to 1.

Ammonium Nitrate Supplementing Commercial Mixtures

Earlier experiments[1] have shown results suggesting no advantage in adding nitrates to tobacco fertilizer mixtures, because the nitrogenous materials employed (viz., oil meals, manures, etc.) will in time fill the requirements for available nitrogen. If ammonium nitrate is added to mixtures, the ammonium radical prevents the inclusion of caustic materials (at least those readily hydrolized), since they cause ammonia to escape.

It is common practice among tobacco growers to apply the greater part of the fertilizer before the crop is planted and the balance as a side dressing between the rows of tobacco, usually at the time of the last row cultivation. The chief purpose of a side dressing is to replenish nitrogen leached from the soil. Thus, it was thought that ammonium nitrate would serve ideally as a side dressing material, with the ammonia nitrogen becoming slowly available and the nitrate part being immediately utilized by the plants.

Therefore, the final series of plots received ammonium nitrate as a side dressing to supplement the nitrogen in an 8-4-8 formula which was reduced as follows to supply a 5-4-8 grade:

480	pounds	castor pomace
400	"	cottonseed meal
124	"	uramon
240	"	superphosphate
480	"	cottonhull ashes (35% K_2O)
160	"	landplaster
116	"	dolomite
2000	pounds	

This formula is sufficiently basic to neutralize the acidifying action both of the nitrogen compounds listed above and the ammonium nitrate added directly to the soil. During a five-year test the above mixture was used at the rate of 2,500 pounds to the acre. Havana Seed tobacco was the test crop. At the time of second hoeing (four to five weeks after planting), the plots received ammonium nitrate at the rate of 230 pounds per acre as a side dressing. In all, the *equivalent* of 2,500 pounds 8-4-8 to the acre had been applied to the land.

The results (Table 7) show that both yield and grading in all five years were on a par or better than the response to cottonseed meal as a single source of nitrogen. Although the favorable results from using this method of fertilization may prove only that several sources of nitrogen produce higher crop values than a single source, it must be pointed out that the unit price of nitrogen in ammonium nitrate is considerably less than that of any of the organic nitrogen carriers. Moreover, the use of ammonium nitrate as a side dressing is very significantly (see Table 7) more advantageous than using the material as a single nitrogen carrier.

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[1] Conn. Agr. Expt. Sta. Bul. 391: 79-82. 1937.

TABLE 7. YIELD AND GRADING RECORDS OF AMMONIUM NITRATE SERIES
(Ammonium Nitrate Supplementing Commercial Fertilizer)

Source of nitrogen	Treat-ment	Blocks	Yield, pounds per acre						Grade index						Crop index	Relative crop value
			1944	1945	1946	1947	1948	Av.	1944	1945	1946	1947	1948	Av.		
2500 lbs. 5-4-8		1	2005	2391	2062	2140	1778	2075	.410	.439	.465	.460	.431	.441		
per acre plus		2	2028	2344	2069	2201	1891	2107	.412	.419	.476	.511	.426	.449		
230 lbs. ammon-	F	3	1737	2297	1908	2166	1927	2007	.375	.434	.406	.492	.450	.431		
ium nitrate per		4	2103	2435	2063	2118	1921	2128	.419	.498	.395	.448	.408	.434		
acre as side dressing			Average					2079						.434	912.7	106.4[1] 113.5[2]
		Average of 5 years for cottonseed meal[3]						2014						.426	858.0	100.0
		Average of 5 years for single application of 200 lbs. N in ammonium nitrate						1955						.411	803.5	100.0

[1] With results from cottonseed meal taken as 100. Significant at odds 19 to 1.
[2] With single application of 200 pounds N in ammonium nitrate taken as 100. Significant at odds 99 to 1.
[3] See Table 2 for individual year and plot figures.

Discussion and Conclusions

Although tobacco in the Connecticut Valley seldom or never is grown with only one single source of nitrogen, it was necessary to conduct the aforesaid experiments in such a way that the specific effect of the material in question could be observed. As in previous tests of this kind with other synthetic materials, oil meals and manures, the results obtained with ammonium nitrate further support the belief that a blend of nitrogen sources favors better quality, if not higher yields.

Ammonium nitrate differs from other nitrate materials in that the basic radical ultimately is reverted to nitrate. The results from nitrification tests indicate that the ammonia is readily changed into a more easily available form. The compound apparently is not so much subjected to denitrification or other types of fixation as is cottonseed meal, because only three-quarters to seven-eighths as much nitrogen of this synthetic material was required to match the results from cottonseed meal.

Used in excess of 175 pounds of nitrogen to the acre, ammonium nitrate causes a slight decrease in crop value. This reduction is contrary to results of earlier experiments on quantity of nitrogen for tobacco[1] where continuous improvement in yield, if not in quality, was found at 250 to 300 pounds nitrogen per acre. To be sure, the increments in the latter case were in terms of organic nitrogen, and these larger quantities are never recommended to the growers.

One reason why there was no improvement in crop value when an apparent excess (200 pounds nitrogen as ammonium nitrate per acre) was employed may be that the plant absorbed ammonium ions to some extent. The relatively low mobility of these ions, especially for tobacco, which favors nitrates, may slow down the nitrogen assimilation in the plant and thus, the vital processes of growth. A contributing factor would be that the equivalent of other basic ions (viz., potassium, calcium, magnesium) are prevented from entering the plant to the extent that ammonium ions are absorbed.

From the results of the experiments as a whole, it is concluded that a maximum of 175 pounds of nitrogen to the acre from ammonium nitrate has a crop producing power almost equal to 200 pounds of nitrogen in cottonseed meal, with both yield and grading evaluated.

The results also have shown that at least 75 pounds of the required 200 pounds nitrogen per acre can be used in the form of ammonium nitrate, and that the blending of nitrogen sources produces better grading than cottonseed meal alone.

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[1] Conn. Agr. Expt. Sta. Bul. 410: 335-353. 1938.

POULTRY MANURE[1]

Frequent inquiries by tobacco growers as to whether poultry manure could be used for tobacco led to an investigation in 1942.[2] At that time only one experiment comparing an application of poultry manure at the rate of 10 tons per acre with the usual commercial fertilizer treatment was made. The results suggested that the manure produced about the same yield and grading as regular commercial fertilizer, but with some impairment of burn.

Since burn of tobacco is a very important factor, this disadvantage might be an objection to the use of poultry manure. It was thought, however, that a part of the commercial fertilizer might be replaced by poultry manure without serious impairment of burn.

Moreover, it was of interest to find out whether plowing under or harrowing in the manure is the better practice. Information was also gathered on the value of the dropping board portion used separately from the litter-mixed material.[3]

In order to test the various ways of using poultry manure, experiments begun in 1947 were carried through 1948 and 1949.

Plan of Experiments

There were eight comparisons with a standard 6-3-6 commercial fertilizer, which was applied at a rate of 3,300 pounds to the acre. This provided about 200 pounds of nitrogen (N), 100 pounds of phosphoric acid (P_2O_5), and 200 pounds of potash (K_2O) per acre. The poultry manure treatments were:

1. All the nitrogen (200 pounds per A.) in the form of dropping board manure, disk-harrowed into the surface soil after plowing.
2. Same as above but plowed under.
3. Half of the nitrogen in dropping board manure; the balance in 6-3-6 commercial fertilizer. All the materials disked in.
4. Same as 3, but the manure plowed under.
5. All the nitrogen furnished from litter-mixed poultry manure, disked in.
6. Same as 5, but plowed under.
7. Half of nitrogen in litter manure, the balance in commercial 6-3-6 fertilizer; all disked in.
8. Same as 7 but the manure plowed under.

Nutrient in Poultry Manure. It is well known that poultry manure has a larger content of nutrient constituents than regular stable manure. The

[1] In cooperation with B. A. Brown, Agronomist, and Stanley Papanos of Storrs Agricultural Experiment Station. The latter now with Soil Conservation Service, Tolland County, Conn.

[2] T. R. Swanback. Poultry manure as tobacco fertilizer. Conn. Agr. Expt. Sta. Bul. 469: 105-106. 1943.

[3] Poultry manure, mixed with bedding, collected from the floors of the chicken houses. In the following pages it will be referred to as litter manure.

following average analysis shows that poultry manure contains twice as much nitrogen and three times as much phosphorus as stable manure.

	Poultry manure	*Stable manure*
Nitrogen (N)	1.0%	.5%
Phosphoric acid (P_2O_5)	1.3%	.4%
Potash (K_2O)	.5%	.5%
Moisture	35.0%	80.0%

Adequate portions of the poultry manure used in the tests were analyzed for nitrogen and potash in order to estimate the requirements needed to match the application of commercial fertilizer. The composition was found to be:

	1947-1948	*1949*
Dropping board manure		
Nitrogen	1.30%	1.12%
Potash	.71%	.70%
Moisture	58%	36%
Litter manure		
Nitrogen	1.90%	2.21%
Potash	.68%	.60%
Moisture	27%	25%

The content of phosphoric acid was fully as high as that of nitrogen and, since we know that the requirements would be more than satisfied, no further attention was paid to this constituent. Luckily, surplus phosphoric acid does not lead to excessive absorption of this constituent.

Nearly eight tons of dropping board manure were required per acre to equal the standard rate of 6-3-6 fertilizer and correspondingly somewhat more than five tons of litter manure.

Culture. The land selected for the tests is a parcel that for generations has been used for tobacco. The soil is a Merrimac sandy loam of fairly high fertility level.

Sufficient land was available to permit triplicate plots for the comparisons listed above, together with three plots receiving commercial fertilizer. The plots were arranged in three blocks, within which the nine treatments were randomized.

Each year at time of plowing, the plow-under portions of poultry manure were applied, and the balance of the manure and all the commercial fertilizers were harrowed in shortly before planting.

Since the manure was deficient in potash, about 280 pounds of sulfate of potash per acre was added when poultry manure alone was used. In our experiments it was applied separately, but in general farm practice a portion of the chemical may be sprinkled on each spreader load of manure intended for the land.

The season of 1947 had sufficient rainfall, hence no irrigation was needed. The crop was in the field between June 7 and August 21.

The early part of the 1948 season was excessively wet. A few plots on the lower elevation of the field showed inferior growth. There was some

nematode infestation, and two plots presented complete failure. The cropping season lasted from June 1 to August 18.

Because of the uneven growth in 1948, the entire field was fumigated after plowing in the spring of 1949. Dry weather prevailed for most of the season, and it was necessary to irrigate the field five times at about a week to 10 days' intervals. There was luxurious growth all through the season and nothing resembling nematode injury could be observed. Plants were set on May 27 and the crop was harvested on August 9.

The average growing period for the three years was 76 days, which is commonly allowed for Havana Seed.

Experimental Results and Comments

In the following, the results from each individual treatment will be discussed and compared with the results from the control plots, where commercial fertilizer, 6-3-6, was used at the rate of 3,300 pounds to the acre. In general farm practice, this formula is the one most extensively used for stalk-cut tobacco in the Connecticut Valley. More often than not a higher rate of application than stated above is used, and with present day prices fertilizer is the costliest item in growing this type of tobacco. For growers who have access to poultry manure, the results discussed below may suggest some real savings in fertilizer costs without impairing the crop value.

All the Nitrogen in Dropping Board Manure. The average results from three years' continuous use of dropping board manure, without addition of commercial fertilizer,[1] as shown in Table 8, do not measure up to those from commercial fertilizer. However, under favorable conditions with fumigated

[1] Except the required potash salt.

TABLE 8. YIELD AND GRADING RECORDS OF POULTRY MANURE EXPERIMENTS. ALL NITROGEN IN DROPPING BOARD MANURE. DISKED VS. PLOWED IN COMPARISON WITH 6-3-6

Treatment	Replicates	Yield Lbs. per acre				Grade index				Av. crop index	Rel. crop value
		1947	1948	1949	Av.	1947	1948	1949	Av.		
Standard	A	1856	1969	2349		.549	.494	.483			
6-3-6	B	1374	1890	1983	1971	.342	.437	.455	.466	918.5	100.0
	C	1969	2227	2119		.472	.503	.456			
All N in	A	1561	1687	2347		.477	.395	.529			
DB	B	1867	1759	2319	1879	.457	.448	.462	.451	847.4	92.3[1]
disked	C	1535	1787	2045		.394	.407	.494			
All N in	A	1594	1702	2430		.453	.356	.488			
DB	B	1420	1717	2067	1854	.340	.341	.480	.407	754.6	82.2[2]
plowed	C	1741	1800	2213		.432	.329	.442			

[1] Significantly lower than check; odds 49-1.
[2] Significantly lower than check; odds 99-1.

soil and the crop irrigated, as in 1949, dropping board manure can be substituted entirely for commercial fertilizer, so far as yield and grading is concerned. Disking in the material after plowing seems to be better than plowing it under.

One-half of the Nitrogen in Dropping Board Manure. When one-half of the fertilizer requirement is furnished as dropping board manure, whether disked in or plowed under, results surpass those obtained with commercial fertilizer alone. The results in Table 9 suggest that plowing under the material is preferable to disking it in. It is of particular interest to note that the quality of the leaf (as judged by grade index) is improved by blending this type of manure with commercial fertilizer.

TABLE 9. YIELD AND GRADING RECORDS OF POULTRY MANURE EXPERIMENTS. HALF OF THE NITROGEN IN DROPPING BOARD MANURE; BALANCE IN COMMERCIAL FERTILIZER. DISKED VS. PLOWED IN COMPARISON WITH COMMERCIAL FERTILIZER

		Yield Lbs. per acre				Grade index					
Treatment	Replicates	1947	1948	1949	Av.	1947	1948	1949	Av.	Av. crop index	Rel. crop value
½ N in	A	1850	1783	2339		.543	.431	.506			
DB disked,	B	1932	1955	2199	1959	.511	.501	.435	.480	940.3	102.4[1]
balance in	C	1688	1681	2201		.506	.411	.476			
comm. fert.											
½ N in	A	1843	1754	2201		.535	.394	.453			
DB plowed,	B	2022	2005	2403	2029	.494	.521	.470	.473	959.7	104.5[2]
balance in	C	1655	2057	2291		.463	.464	.459			
comm. fert.											
Standard 6-3-6	Average from Table 8				1971				.466	918.5	100.0

[1] Not significant.
[2] Significant at odds less than 19-1.

All the Nitrogen in Litter Manure. For some unknown reason "all-manure" application for tobacco in the form of litter manure has a somewhat better showing than the use of dropping board manure alone to furnish the fertilizer requirement. However, it is still indicated (Table 10) that commercial fertilizer produced somewhat better yield and grading than "all-manure" under a tobacco crop.

One-half of the Nitrogen in Litter Manure. Half and half of litter manure and commercial fertilizer produced tobacco of almost the same yield and quality as commercial fertilizer alone. It makes little difference whether the manure is disked in or plowed under. It should be recalled that about one-third less of the litter material than of the dropping board manure was required per acre on a tonnage basis. Thus, it is possible that the nutrients in the former could be more fully utilized than those in the dropping board material.

TABLE 10. YIELD AND GRADING OF POULTRY MANURE EXPERIMENTS. ALL N IN LITTER MANURE. DISKED VS. PLOWED IN COMPARISON WITH COMMERCIAL FERTILIZER

Treatment	Repli-cates	Yield Lbs. per acre 1947	1948	1949	Av.	Grade index 1947	1948	1949	Av.	Av. crop index	Rel. crop value
All N in	A	1768	1755	2281		.492	.339	.511			
litter man-	B	1653	1953	2333	1939	.476	.417	.446	.456	884.2	96.3[2]
ure, disked	C	1759	1800	2152		.459	.463	.501			
All N in	A	1747	1744	2354		.527	.305	.454			
litter man-	B	1733	1950	2046	1908	.480	.446	.466	.444	847.2	92.2[3]
ure, plowed	C	1720	1704	2177		.432[1]	.447	.437			
Standard 6-3-6	Average from Table 8				1971				.466	918.5	100.0

[1] Estimated data.
[2] Significantly lower than check; odds 19-1.
[3] Significantly lower than check; odds 49-1.

TABLE 11. YIELD AND GRADING OF POULTRY MANURE EXPERIMENTS. HALF N IN LITTER MANURE. DISKED VS. PLOWED IN COMPARISON WITH COMMERCIAL FERTILIZER

Treatment	Repli-cates	Yield Lbs. per acre 1947	1948	1949	Av.	Grade index 1947	1948	1949	Av.	Av. crop index	Rel. crop value
½ N in	A	1908	1652	2239		.504	.367	.470			
litter	B	1458	1729	1978	1935	.491	.377	.436	.462	894.0	97.3[1]
disked	C	1935	2177	2340		.551	.494	.470			
½ N in	A	1863	1828	2171		.494	.436	.442			
litter	B	1446	1641	2160	1942	.389	.412	.472	.457	887.5	96.6[2]
plowed	C	1921	2250	2194		.517	.497	.451			
Standard 6-3-6	Average from Table 8				1971				.466	918.5	100.0

[1] Not significantly lower than check.
[2] Significantly lower than check; odds 19-1.

Burning Qualities of the Leaf

A tobacco crop, no matter how satisfactory in yield and grading quality, will not sell, if the burn is not satisfactory. Therefore, one of the major efforts of the experienced grower is to produce tobacco with proper burning qualities. Occasional users of poultry manure have complained that tobacco fertilized with it burns poorly. To be sure, poultry manure contains more chlorine than stable manure, and it is commonly known that this element retards fire.

Potash, however, is the constituent in a tobacco leaf that promotes burn. Therefore, a high chlorine content may be counteracted by additions of potash to the fertilizer mixture.

The burn of the leaf, or its fire-holding capacity, is tested in this Laboratory by touching the taut leaf against a hot electric filament. The number of seconds the ignited spot will continue to glow is recorded.

Burn tests were made each year on leaf samples from the three crops. Two years' results are listed in Table 12.

TABLE 12. RESUMÉ OF TWO YEARS RESULTS FROM BURN TESTS ON TOBACCO FROM POULTRY MANURE EXPERIMENTS

Treatment	Duration of burns (seconds) 1947	1948
Check (6-3-6)	33.2	26.6
All N, DB, disked	15.1	7.9
All N, DB, plowed	29.9	18.7
½ N, DB, disked	34.0	26.4
½ N, DB, plowed	31.4	20.9
All N, litter, disked	24.3	13.6
All N, litter, plowed	25.1	15.5
½ N, litter, disked	29.8	17.6
½ N, litter, plowed	34.9	18.5
Annual average for manure	28.0	17.4
Relative annual trend for manure	100	62
Same for check	100	80

Burn, equally good as the "Check", was obtained by using half disked-in dropping board manure and half commercial fertilizer. This result, however, is an exception rather than the rule, since results from the other manure treatments are lower than the check. It should be noticed also that 1947 was a "better-burn year" than 1948, since the burn duration in 1948 was lower by 20 per cent for the commercial fertilizer and as much as 38 per cent for the manure.

It is of interest to note that, with the one exception mentioned above, better burn resulted from plowing under the manure and employing the method of half manure and half commercial fertilizer than by disking and use of all manure. It is possible that, by plowing under the material, less of the manure particles would come into direct contact with the roots and, therefore, less chlorine would be absorbed before this is thoroughly dispersed in the soil.

Random sampling of the 1949 crop showed excellent burn throughout, hence no systematic tests were made. Irrigation[1] and possibly the soil

[1] Conn. Agr. Expt. Sta. Bul. 334: 164.

fumigation[1] might have been contributing factors in making an abundance of potash available, hence a promotion of burn.

The relation of chlorine and potash in their effect on burn was studied on samples of 1948 crop. Analyses were made for potassium and chlorine and compared with the effect on burn; the results are recorded in Table

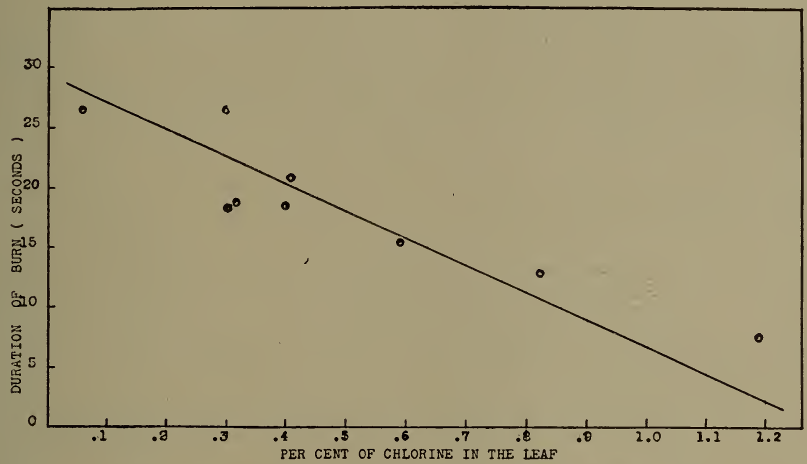

Figure 2. Graph showing the relation of chlorine to burn of tobacco from poultry manure experiments. Crop of 1948.

TABLE 13. LEAF CONTENT OF CL AND K, AND BURN OF TOBACCO[1] IN 1948 POULTRY MANURE EXPERIMENT (Average of "Darks" and "Seconds")

Treatment	Percentage in the dry leaf of: Cl	K	Duration of burn (seconds)
Check (6-3-6)	.06	5.13	26.6
½ N in DB disked	.31	4.40	26.4
½ N in litter plowed	.32	4.10	18.5
All N in DB plowed	.33	4.34	18.7
½ N in litter disked	.40	4.15	17.6
½ N in DB plowed	.42	4.12	20.9
All N in litter plowed	.59	4.50	15.5
All N in litter disked	.83	4.17	13.6
All N in DB disked	1.17	4.67	7.9

[1] One series of samples, selected at random.

[1] Conn. Agr. Expt. Sta. Bul. 542: 20.

13. From these data the graph in Figure 2 was constructed. It is evident that with increasing chlorine there is a steady decrease in the duration of burn. There was no direct relation of potassium content to leaf burn.

Discussion

In farm practice, poultry manure as applied to the field is a mixture of dropping board material and the waste from the floors. The experiments discussed above had indirectly suggested that use of such a mixture is the best practice. Contrary to common opinion, the litter mixed manure is almost as valuable as the solids deposited on the dropping board, possibly on account of its lower moisture and the content of wasted feed.

In the following resumé of the three years' results, the commercial fertilizer ranks third on the list.

Treatment	*Relative crop value*
½ dropping board manure, plowed	104.5
½ dropping board manure, disked	102.4
Commercial fertilizer, 6-3-6	100.0
½ litter manure, disked	97.3
½ litter manure, plowed	96.6
All litter manure, disked	96.3
All dropping board manure, disked	92.3
All litter manure, plowed	92.2
All dropping board manure, plowed	82.2

It seems clear that the half dosage of dropping board manure (with the balance in commercial fertilizer) produced equally good crop values as commercial fertilizer alone. As stated above, however, mixed manure is to be preferred.

Theoretically, half dosage of dropping board manure and litter-mixed material would give a relative figure of 100. In other words, it would mean that poultry manure used on this basis is fully comparable to the use of commercial fertilizer alone.

With the low content of potash in poultry manure, it is important to furnish additional amounts of this constituent in some form. If the manure is composted, it could be layered with tobacco stalks or stems; otherwise the manure may be enriched with 40 to 50 pounds of sulfate of potash per ton, or the equivalent of other forms of potash (obviously excluding muriates).

If potash was not added, either in storing or in application, there is still time to give extra potash when side dressing the crop. Nitrate of potash may then be one of the materials used. The need for this "potash precaution", however, is not so important if the soil is high to extremely high in available potash, as when there is only a medium or low content of this constituent.

SUMMARY

Experiments with ammonium nitrate have been carried on for five years; with poultry manure for three years. The results reported here may be summarized as follows.

Ammonium nitrate as the only source of nitrogen in tobacco fertilizer mixtures did not quite measure up to the results obtained with cottonseed meal.

It was shown that 175 pounds of nitrogen to the acre from ammonium nitrate resulted in nearly the same crop value received from 200 pounds of cottonseed meal nitrogen. Under favorable conditions, that is, with no appreciable amount of leaching, 150 pounds of nitrogen from ammonium nitrate matched the results obtained with cottonseed meal.

The soil nitrate levels produced by 200 pounds of cottonseed meal nitrogen were equalled by the 150 pound rate of nitrogen from ammonium nitrate in certain years and surpassed by the higher rates. Thus, the ammonium radical of the material was readily converted to available nitrogen.

Most promising results were obtained with ammonium nitrate as a side dressing to supplement a 5-4-8 formula, thus furnishing sufficient plant food to equal an 8-4-8 grade. Both yield and grading were somewhat better than those obtained from the cottonseed meal, applied as the only source of nitrogen. It is indicated that several sources of nitrogen are more favorable than a single one.

Poultry manure is a valuable fertilizer material and generally contains (on a fresh basis) 1 per cent N, 1.3 per cent P_2O_5 and 0.5 per cent K_2O, thus about twice to three times as much of the first two constituents as regular stable manure.

The use of poultry manure for stalk-cut tobacco was compared with commercial fertilizer.

Experiments were made to measure the effect of using dropping board manure separately from the litter-mixed materials on the floors.

Dropping board manure contained 1.12 to 1.3 per cent N and .7 per cent K_2O; litter manure about 2 per cent N and .6 to .7 per cent K_2O.

Plowing under versus harrowing in the manure was tried in one series of experiments. Another series included a test in which half poultry manure and half commercial fertilizer was used. These treatments were compared with manure alone and commercial fertilizer alone.

Results indicated that litter-mixed material is about as valuable as that from dropping boards.

With respect to crop value received, there was little or no difference between plowing under and harrowing in the manure, but somewhat better burn was obtained by plowing under the manure.

The best practice seemed to be the use of half manure and half commercial fertilizer.

Since poultry manure is relatively low in potash, it is suggested that extra potash be applied or that the manure be enriched with potash-carrying materials.